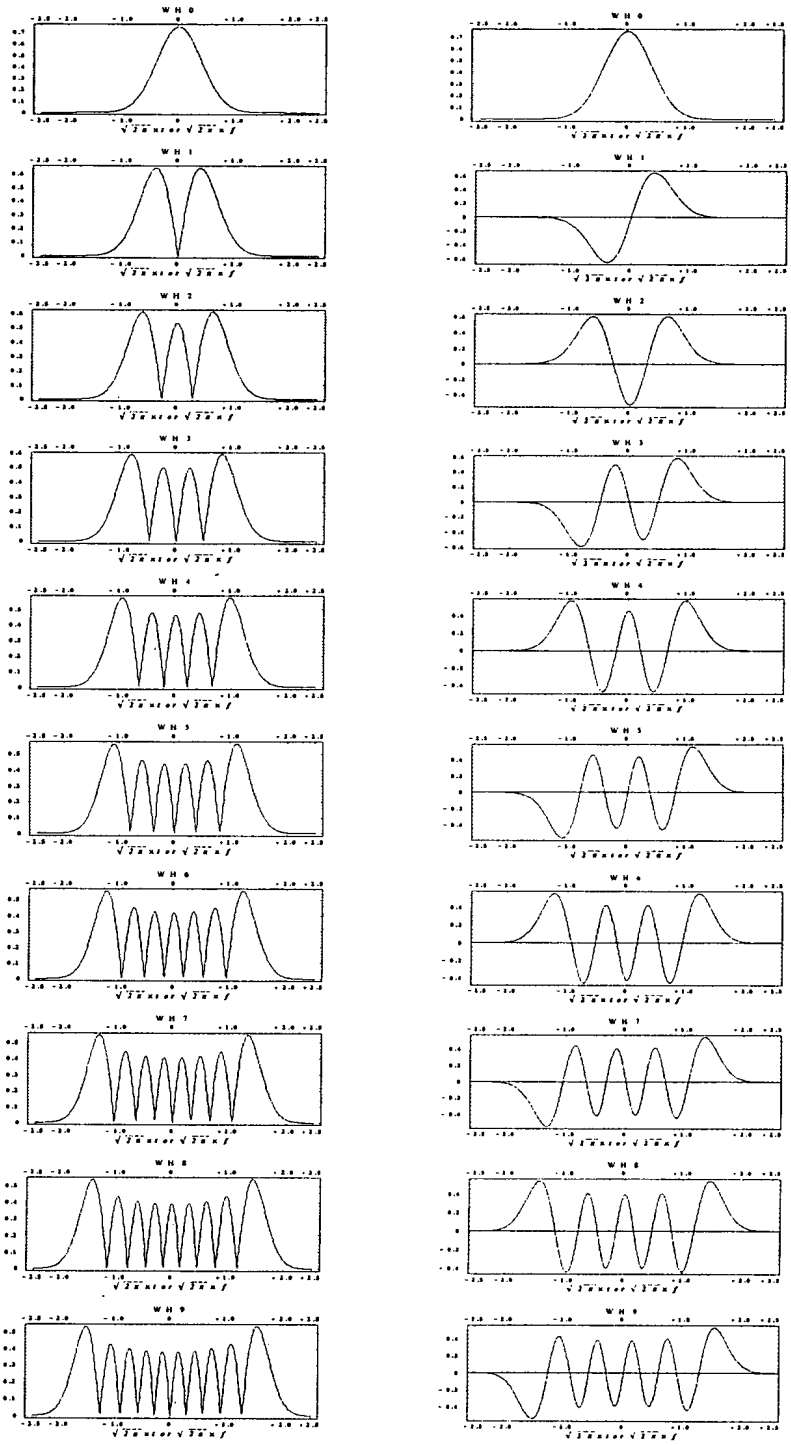


Fig 1 Left column: absolute values for the first 10 WH signals (WH0 – WH9, top to bottom) in both time and frequency domains. Right column: real values for the same 10 WH signals in the time domain.

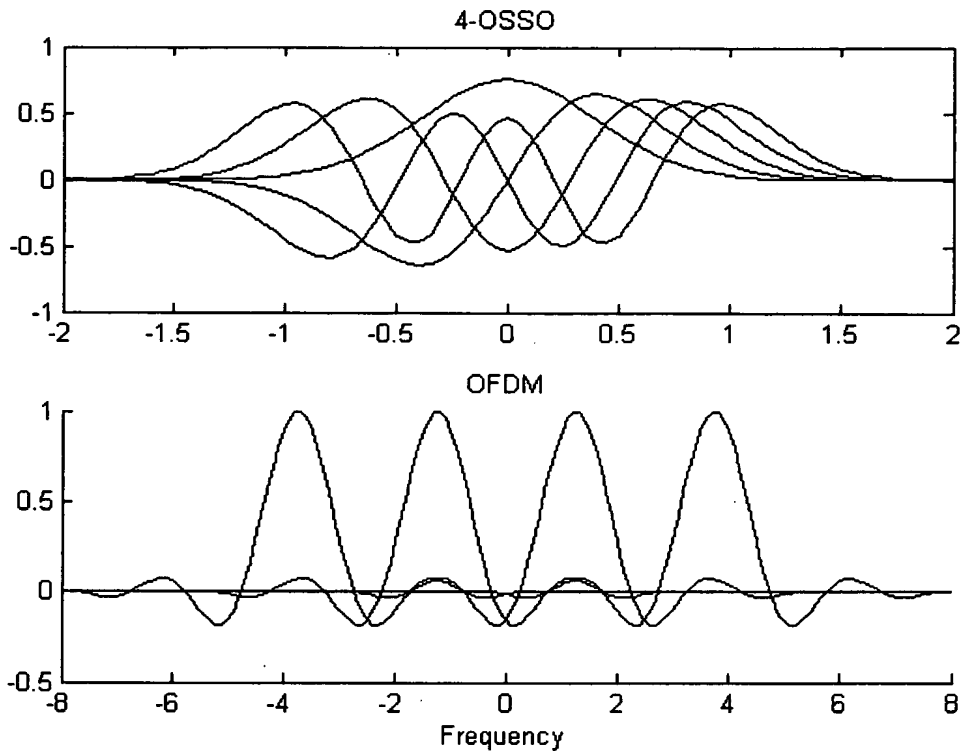


Fig 2 Top: the envelope of an OSSO symbol composed of four WH signals – hence 4-OSSO represented in both the time and frequency domains. Bottom: an Orthogonal Frequency Division Multiplexing (OFDM) symbol in the frequency domain. In the case of OSSO, signal orthogonality is a due to zero cross-correlation of the WH signals. In the case of OFDM, signal orthogonality is due to the displacement of the frequency content of each signal in the frequency domain.

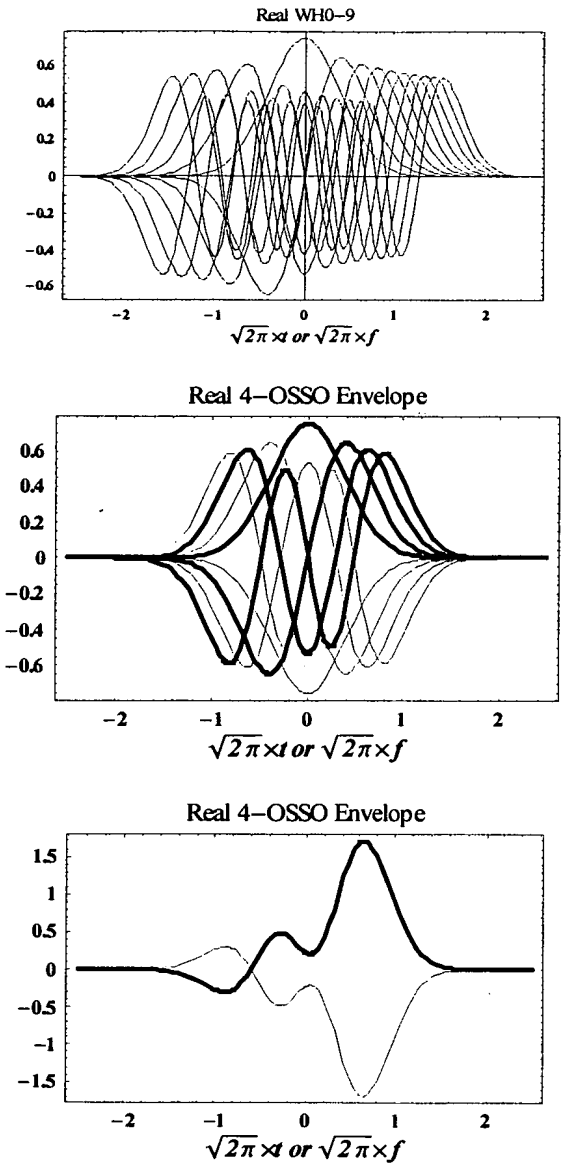


Fig 3 Top: Representation of the envelope of a 10-OSSO symbol showing 10 WH signals (WH0 – WH9) before summation, and in both the time and frequency domains and in either I or Q; Middle: Representation of the envelope of a 4-OSSO symbol showing 4 WH signals (WH0 – WH3) before summation, and in both the time and frequency domains and in either I or Q. Bottom: Representation of the envelope of a 4-OSSO symbol after summation in both the time and frequency domains and in either I or Q.

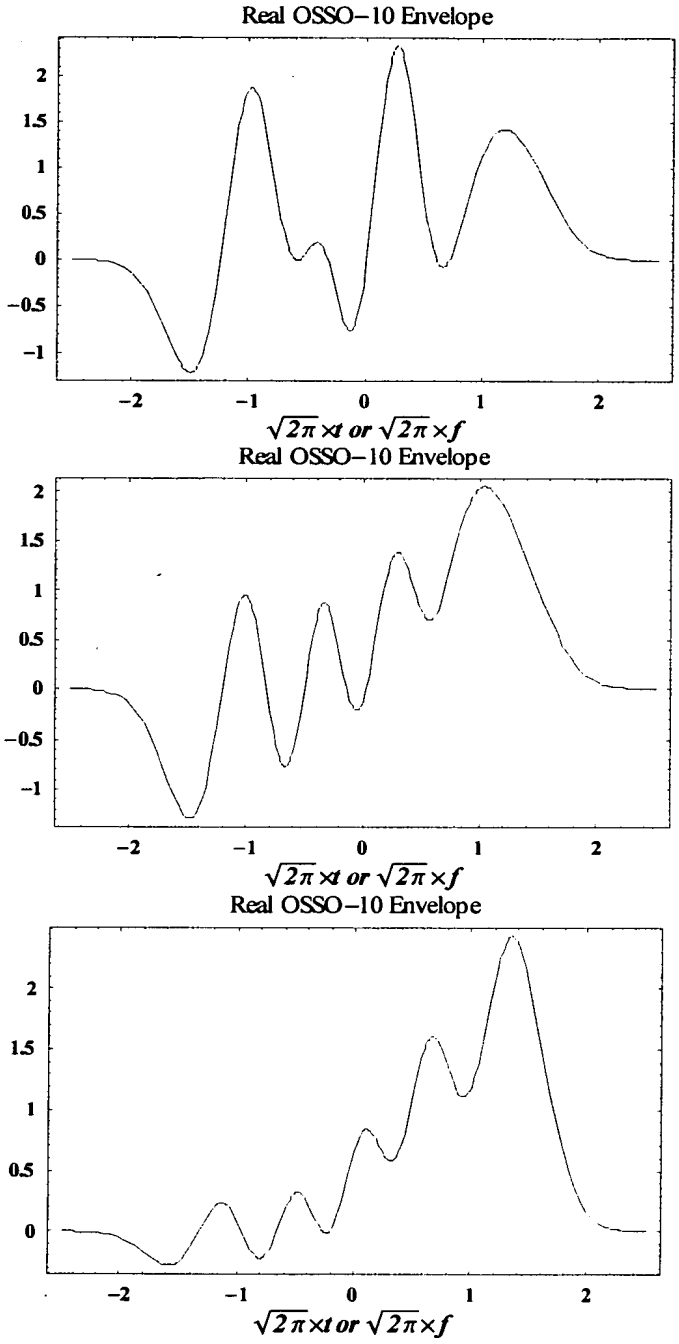


Fig 4 Representative examples of 10-OSSO symbols in either the time or frequency domain after summation and in either I or Q.

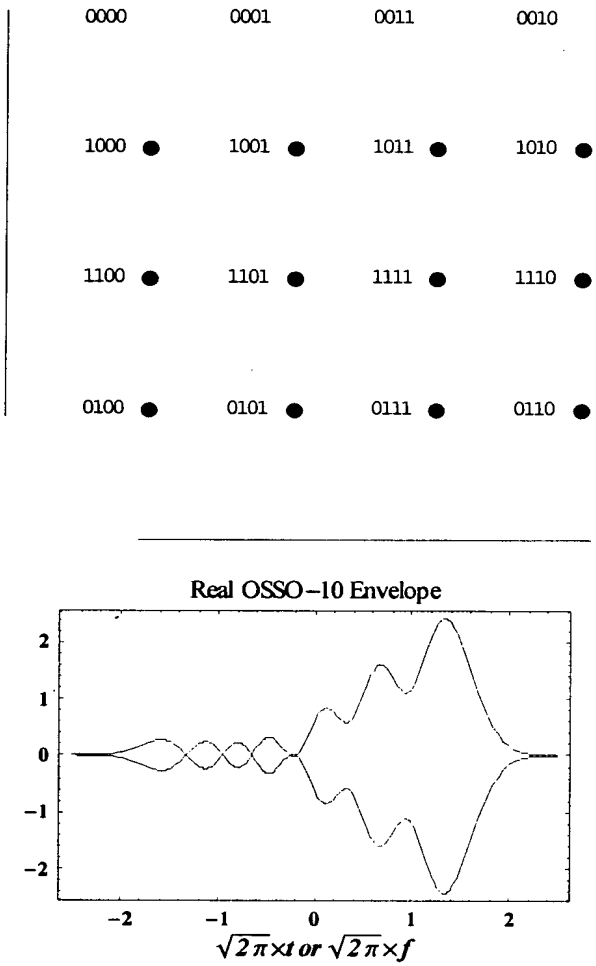


Fig 5 Top: 16-QAM constellation. Bottom: representative 10-OSSO in either the time or frequency domains and in either I or Q. Each of the WH signals in an OSSO symbol is independently modulated according to a QAM scheme in I and Q.

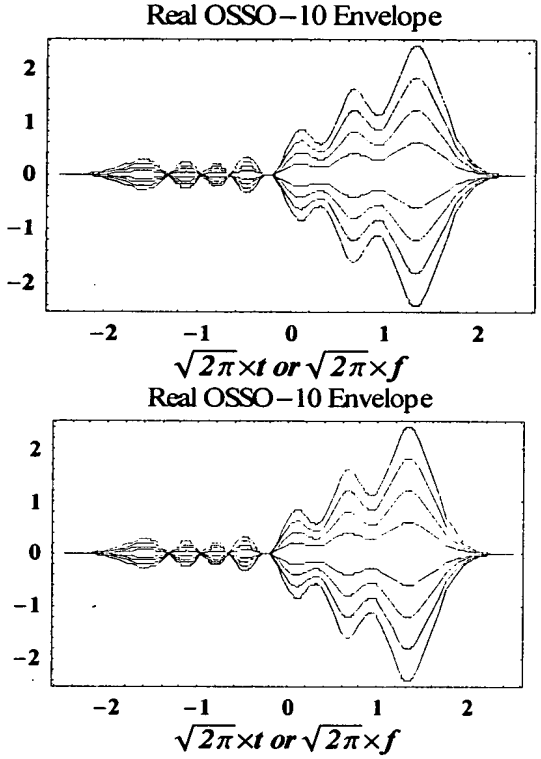


Fig 6 Representative 10-OSSO symbols in the time or frequency domains and in I or Q showing possible amplitude levels and with all WH signals equally amplitude modulated.

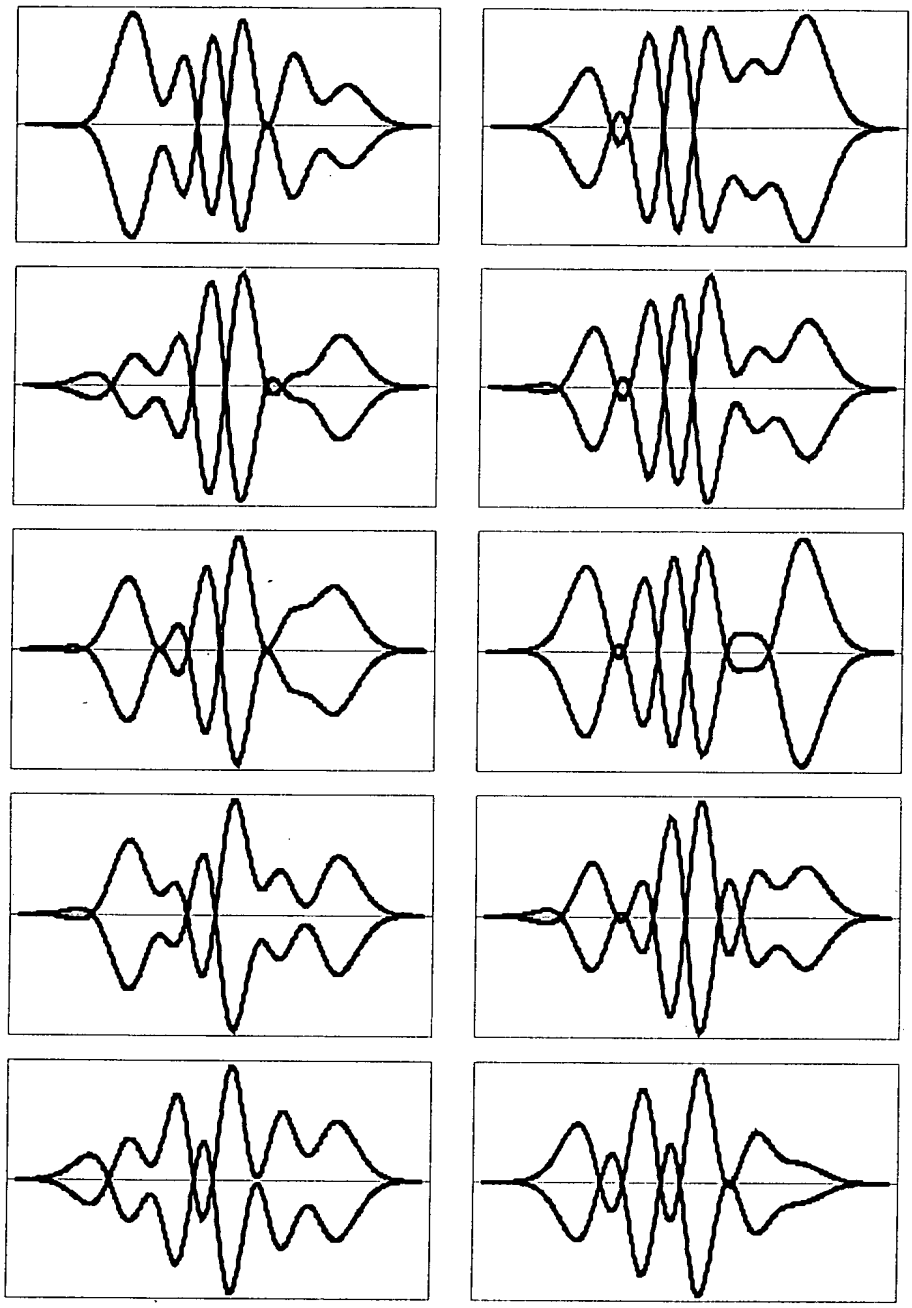


Fig 7 Representative 10-OSSO symbols with all WH signals independently amplitude modulated and in either I or Q.

CROSS-CORRELATIONS: TIME DOMAIN

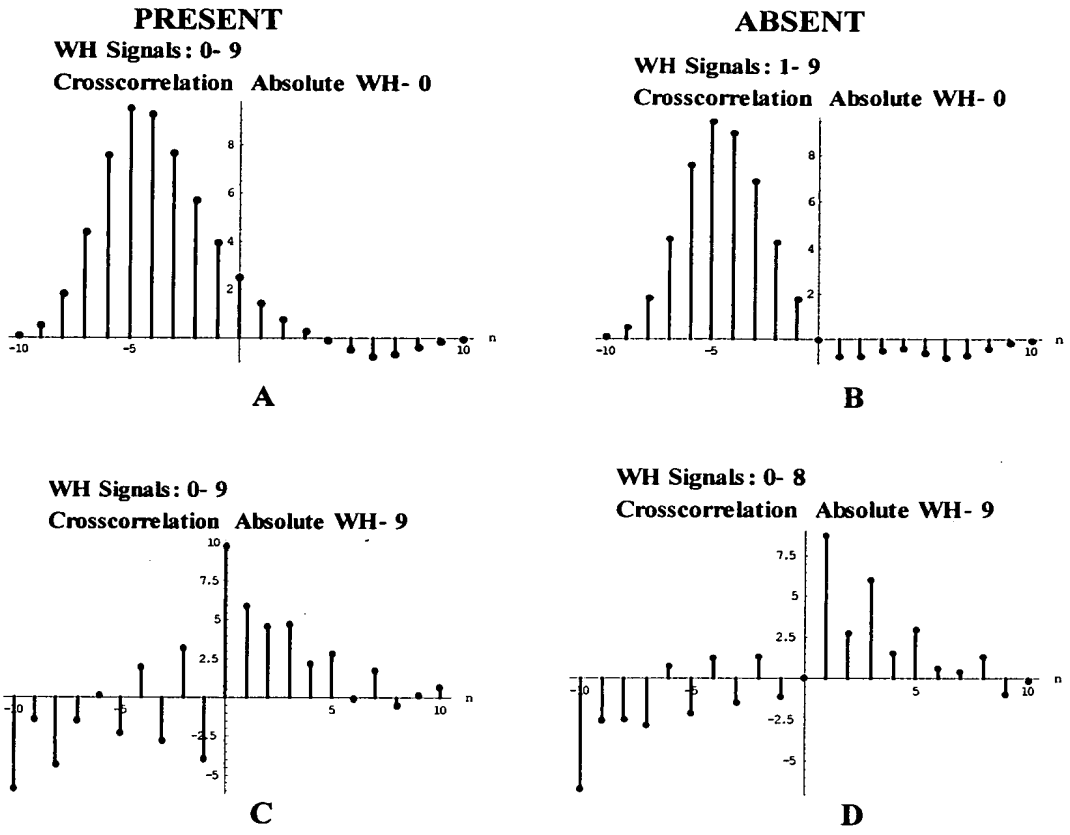


Fig 8A Examples of cross-correlations of signal templates with OSSO symbols in the time domain. Cross-correlations of A: The WH0 signal template with a 10-OSSO symbol in which WH0 is present, and B: with a 9-OSSO symbol in which the WH0 signal is absent. In A, there is a finite amplitude at the zeroth time position; in B the amplitude is zero. Cross-correlations of C: The WH9 signal template with a 10-OSSO symbol in which WH9 is present, and D: with a 9-OSSO symbol in which the WH9 signal is absent. In C, there is a finite amplitude at the zeroth time position; in D the amplitude is zero.

CROSS-CORRELATIONS: FREQUENCY DOMAIN

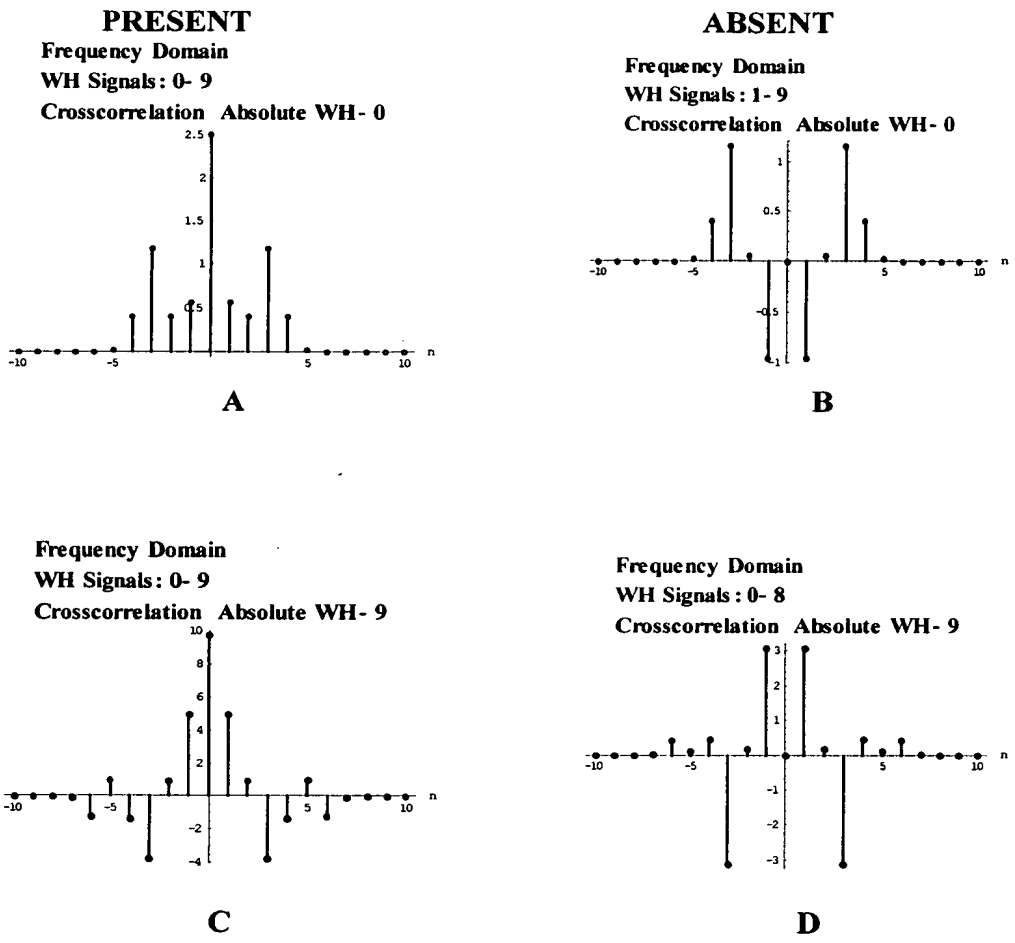


Fig 8B Examples of cross-correlations of signal templates with OSSO symbols in the frequency domain. Cross-correlations of A: The WH0 signal template with a 10-OSSO symbol in which WH0 is present, and B: with a 9-OSSO symbol in which the WH0 signal is absent. In A, there is a finite amplitude at the zeroth time position; in B the amplitude is zero. Cross-correlations of C: The WH9 signal template with a 10-OSSO symbol in which WH9 is present, and D: with a 9-OSSO symbol in which the WH9 signal is absent. In C, there is a finite amplitude at the zeroth time position; in D the amplitude is zero.

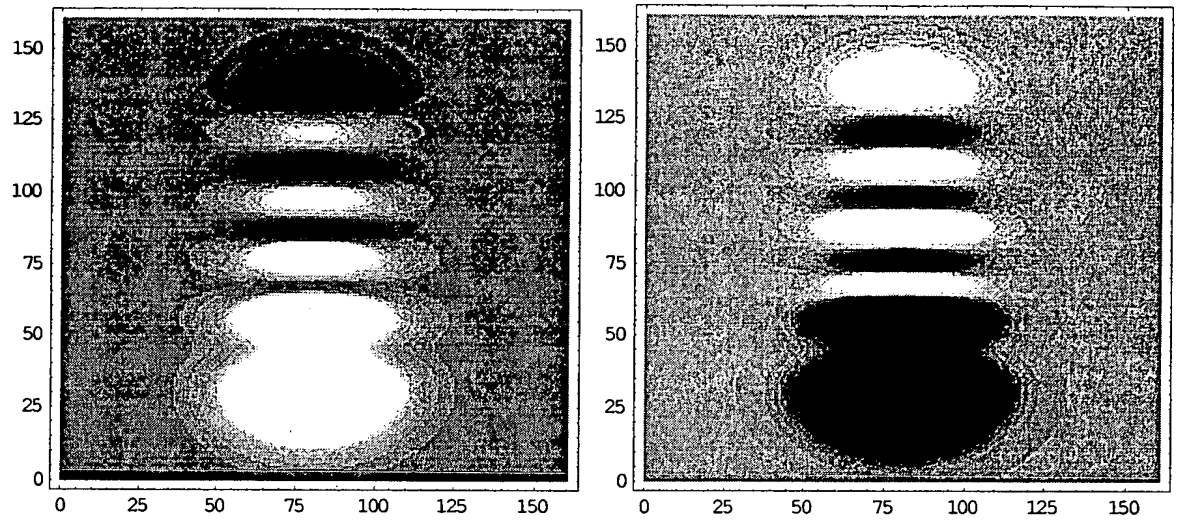


Fig 9A: Outer products of WH0 and 10-OSSO symbol with WH0 Present (left) and Absent (right) from OSSO symbol.

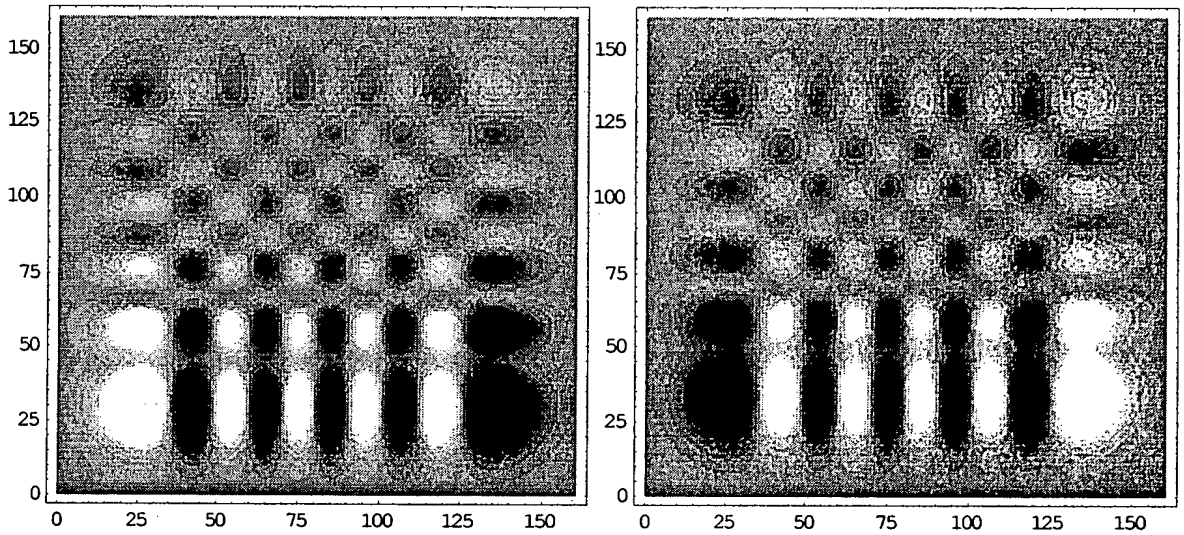


Fig 9B: Outer products of WH9 and 10-OSSO symbol with WH9 Present (left) and Absent (right) from OSSO symbol.

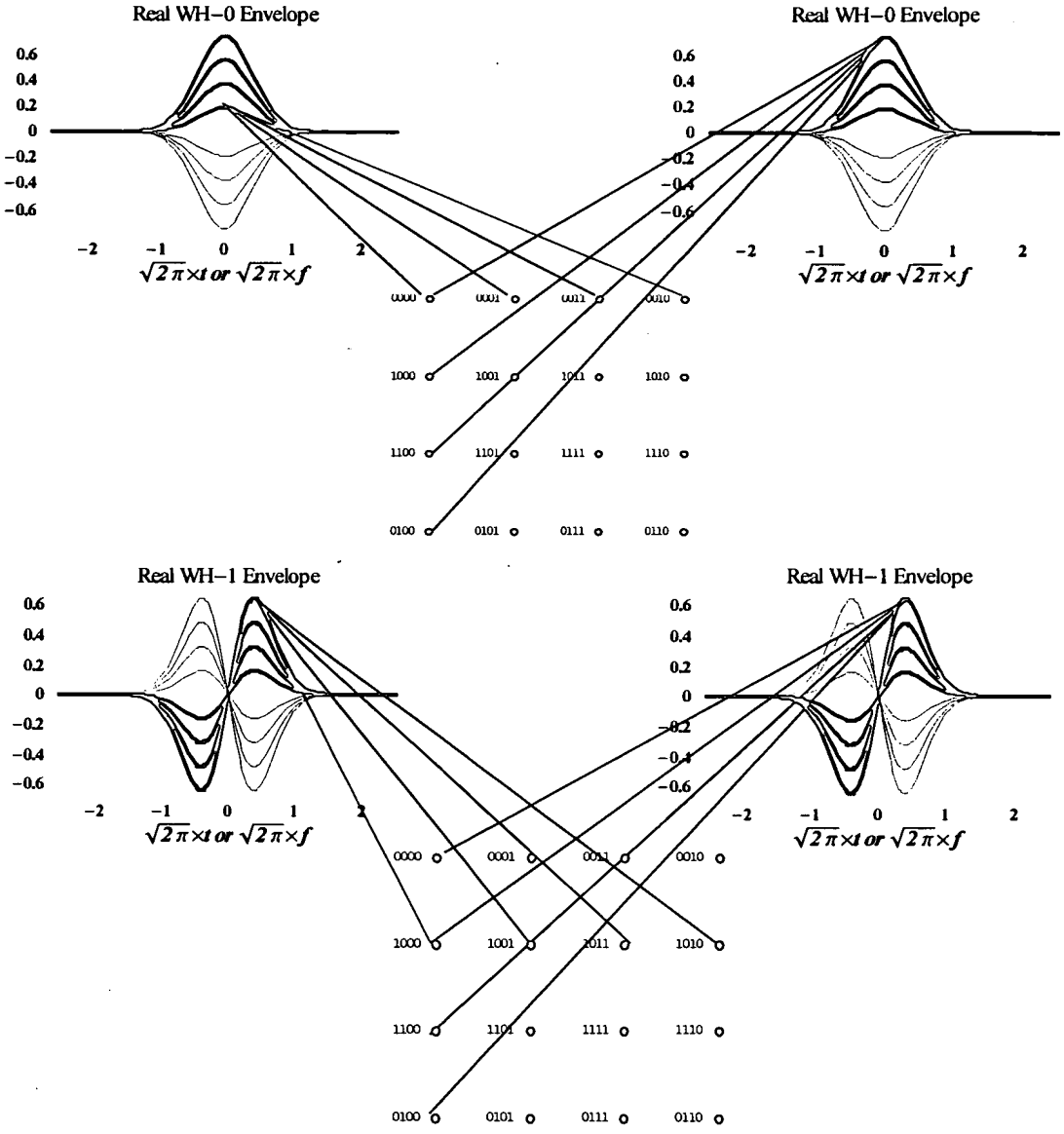


Fig 10A Top: WH0 in I (left) and Q (right) showing amplitude level relationship to a 16-QAM constellation. Bottom: WH1 showing the same relationship but to a separate 16-QAM constellation.

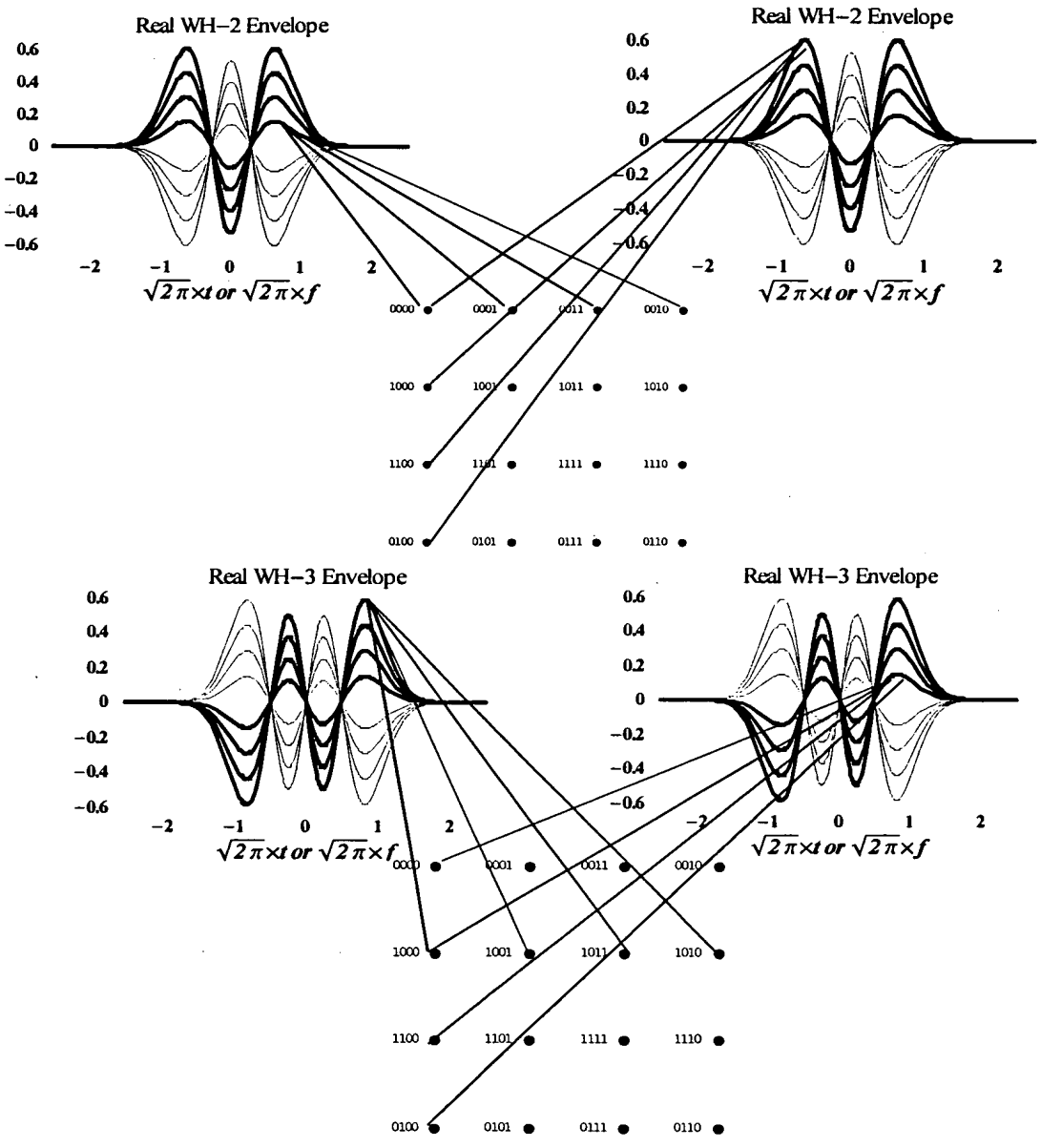


Fig 10B Top: WH2 in I (left) and Q (right) showing amplitude level relationship to a 16-QAM constellation. Bottom: WH3 showing the same relationship but to a separate 16-QAM constellation.

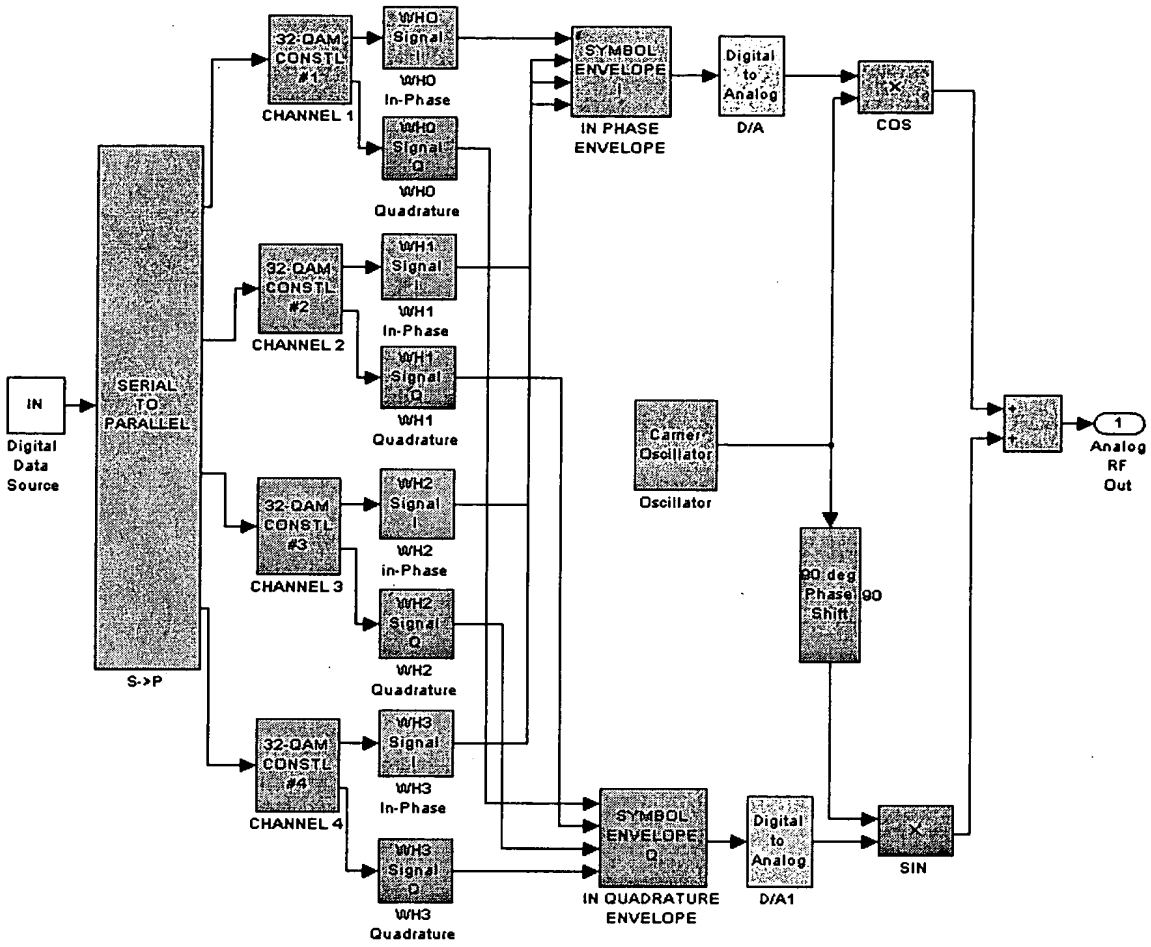


Fig 11A Representative OSSO transmitter: 4-OSSO-32 in which the OSSO symbol is constituted of four WH signals: WH0, WH1, WH2 and WH3, each of which is modulated in I and Q to form four separate 32-QAM channels. This representation is for illustration purposes as many functions can be performed in software and programmable devices such as FPGAs and DSPs.

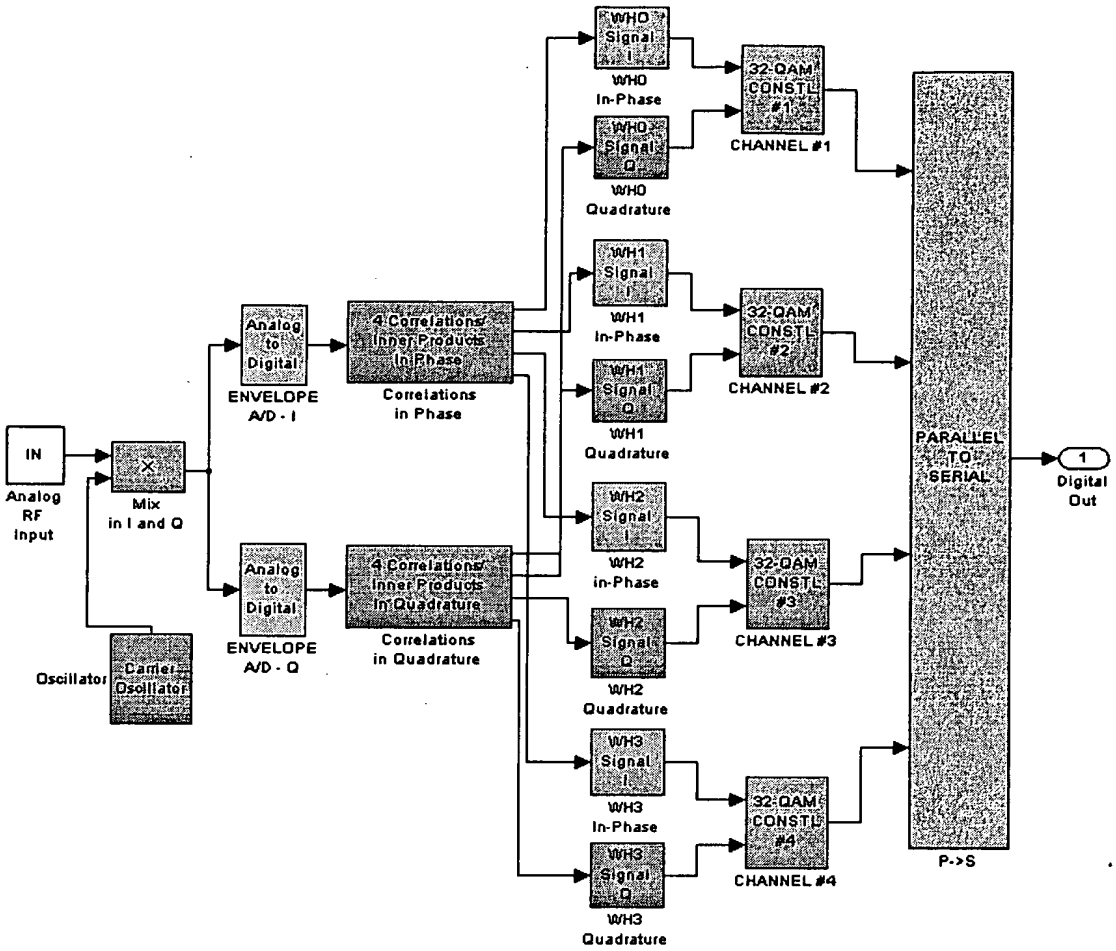
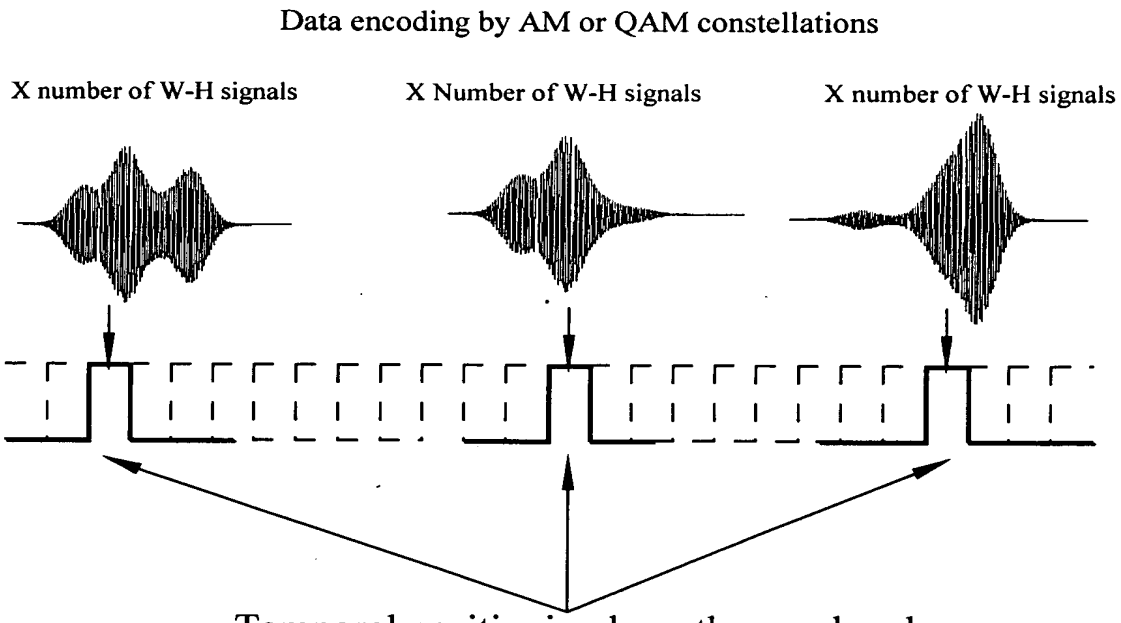


Fig 11B Representative OSSO receiver: 4-OSSO-32 in which the OSSO symbol is constituted of four WH signals: WH0, WH1, WH2 and WH3, each of which has been modulated in I and Q to form four separate 32-QAM channels. This representation is for illustration purposes as many functions can be performed in software and programmable devices such as FPGAs and DSPs.

ANALOG: Orthogonal Signal Spectral Overlay (OSSO)



DIGITAL: Orthogonal Code Schemes (OCS)

Both TDMA and CDMA possible

Fig 12 Representation of positioning of transmitted OSSO symbols using either TDMA or CDMA codes.